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# (12) UK Patent Application (19) GB (11) 2 346 680 (13) A

(43) Date of A Publication 16.08.2000

(21) Application No 9903050.4

(22) Date of Filing 11.02.1999

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(51) INT CL<sup>7</sup>

**F25B 39/04 // F28F 9/02 9/22**

(52) UK CL (Edition R )

**F4H HGXB HG2L**

(56) Documents Cited

**EP 0769666 A1      US 5752566 A      US 5730212 A**  
**US 5228315 A      US 5076354 A**

(58) Field of Search

**UK CL (Edition Q ) F4H HGXB HG17**  
**INT CL<sup>6</sup> F25B 39/04 , F28F 9/02 9/22**  
**Online: EPODOC, JAPIO, WPI**

(54) Abstract Title

**Condenser**

(57) A condenser 1 for use in an air conditioning or refrigeration system has refrigerant flowpaths extending adjacent one another and grouped 7a-7e such that adjacent groups 7a-7e carry refrigerant passes in opposed directions across the condenser. The arrangement of groups 7a-7e is such that the number of refrigerant passes across the condenser 1 is 5 or above. The refrigerant flowpaths may comprise tubes 6 extending across the condenser 1.

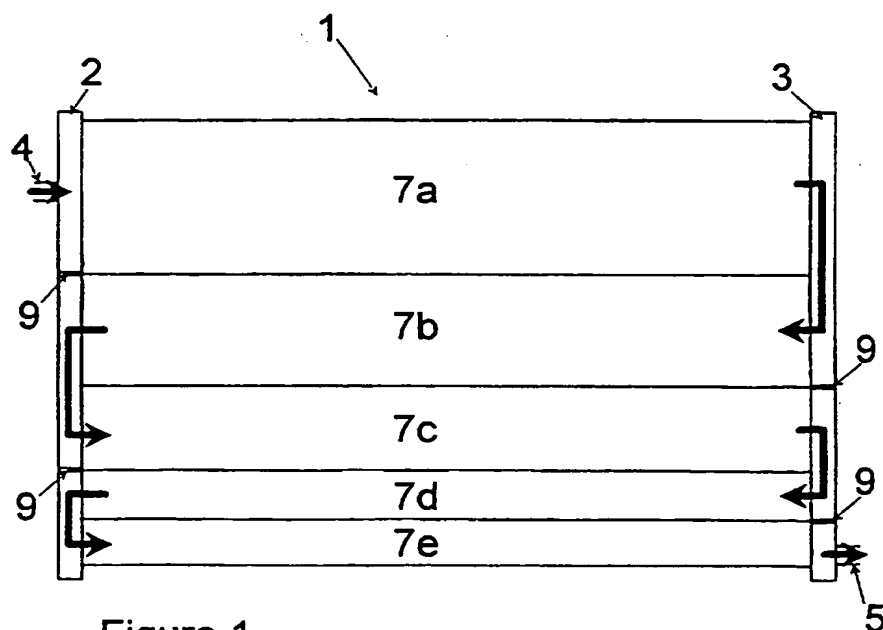


Figure 1

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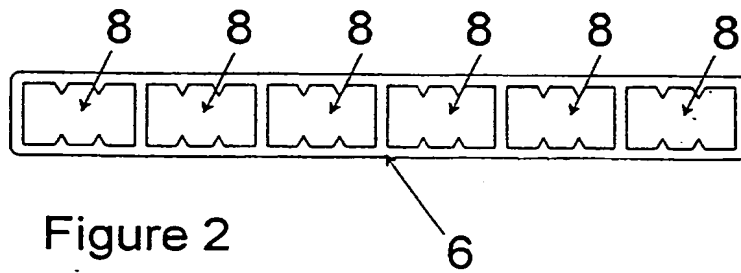
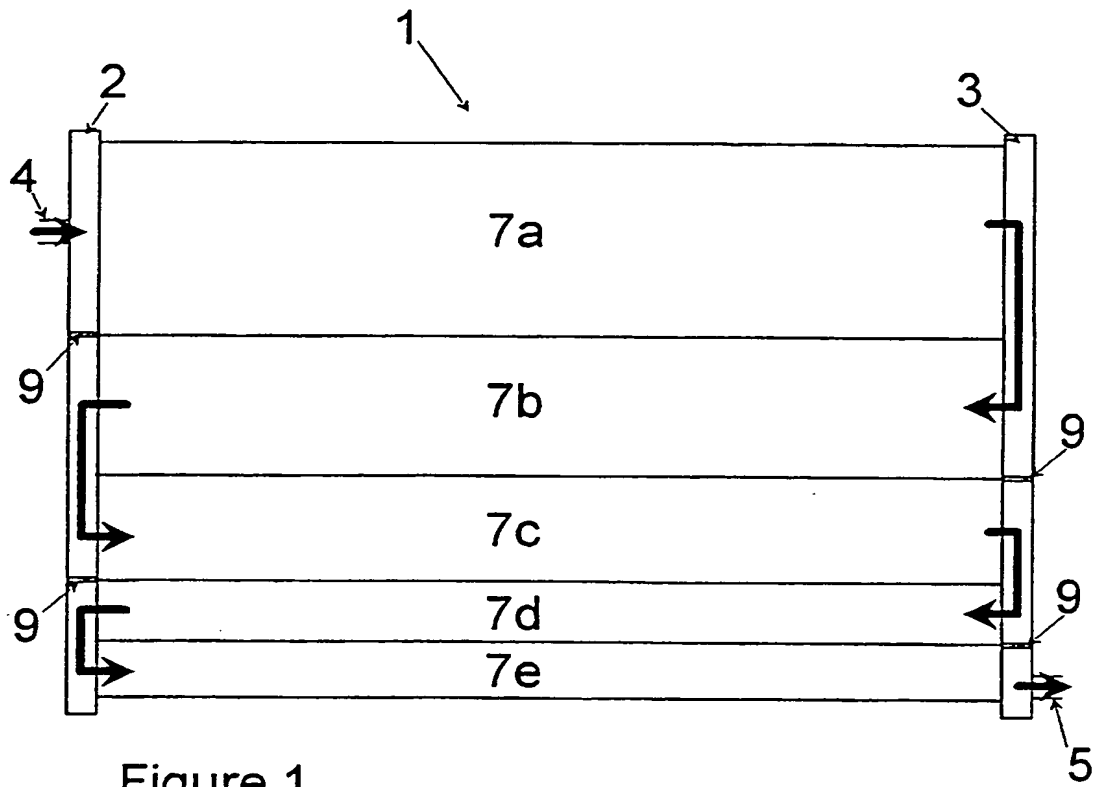


FIG 3

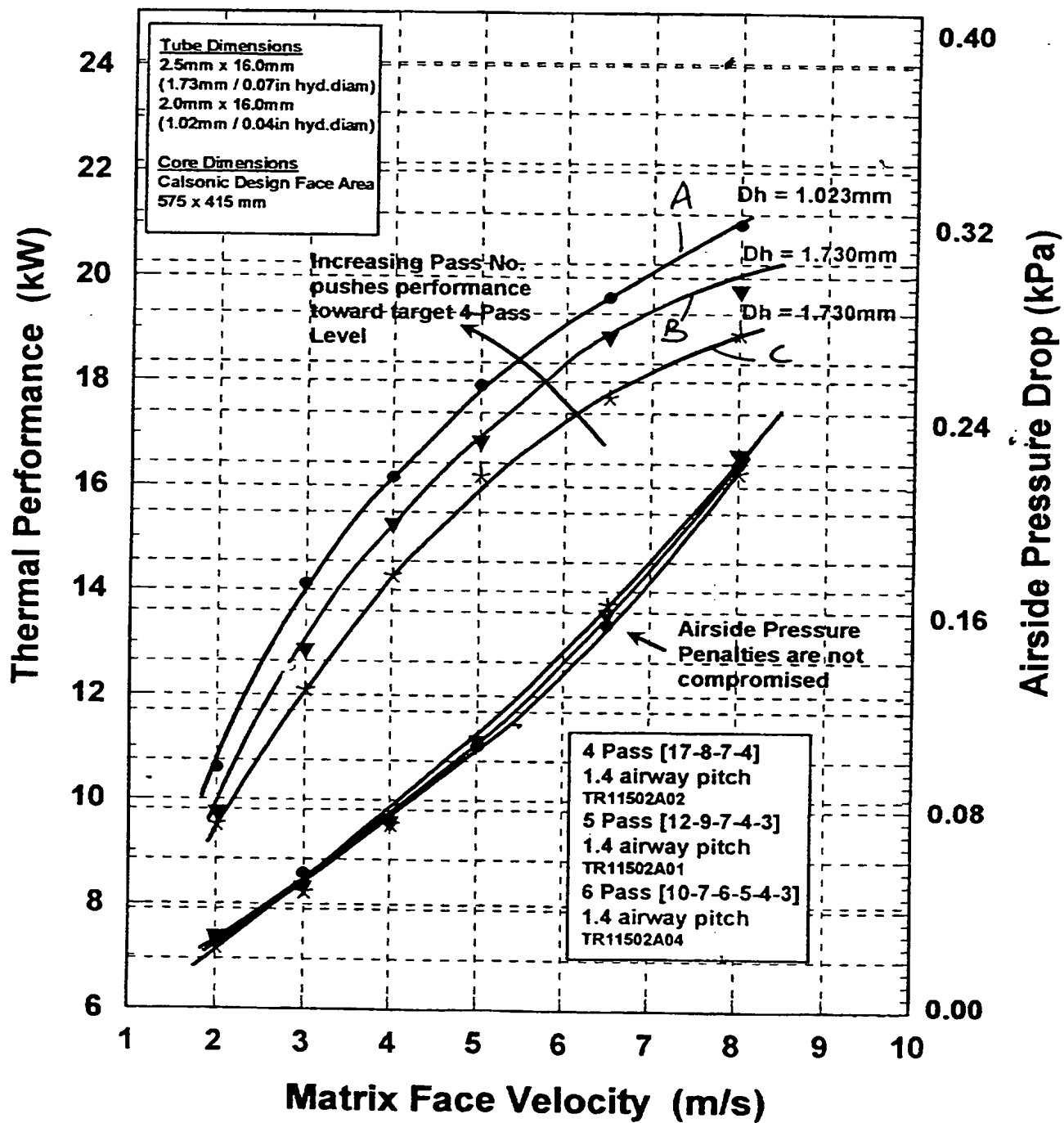
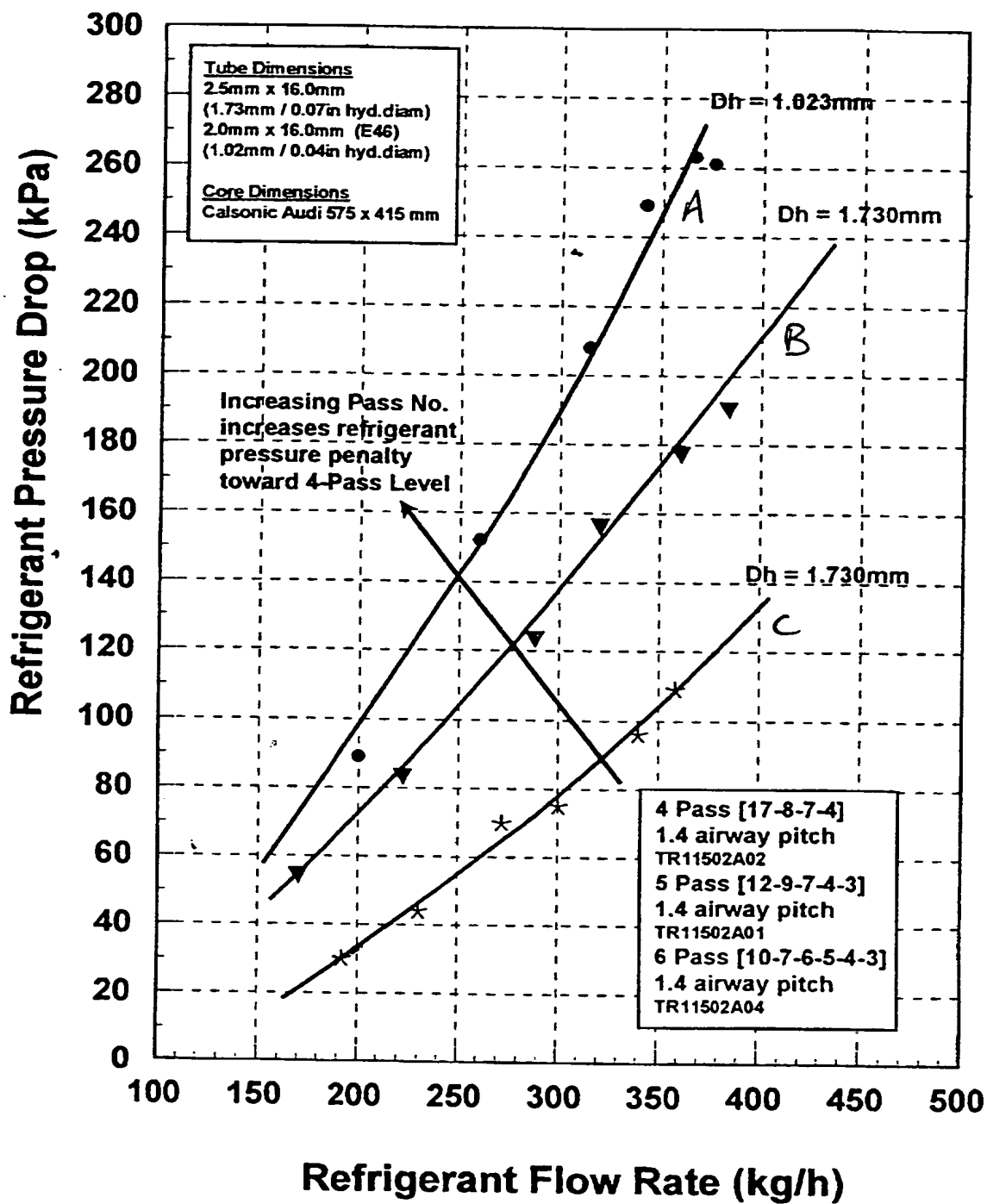


FIG 4.



A Condenser

5 The present invention relates to a condenser, and in particular to a condenser for use in an air conditioning or refrigeration system (particularly for automotive use).

10 EP-B-0219974 discloses a condenser for an automotive refrigeration/air conditioning system in which condenser refrigerant flow tubes have a hydraulic diameter in the range 0.381mm to 1.778mm. Hydraulic diameters at approximately 0.9mm are said to optimise ultimate heat transfer efficiency.

15 An improved condenser has now been devised.

According to the invention, there is provided a condenser for use in an air conditioning or refrigeration system, the condenser comprising a plurality of refrigerant flowpaths extending adjacent one another, said flowpaths being grouped such that adjacent groups carry refrigerant passes in opposed directions across the condenser, wherein the arrangement of groups is such that the number of refrigerant passes across the condenser is 5 or above.

25 It has been found that, particularly for flowpaths having hydraulic diameters toward the upper end of the preferred range specified in EP-B-0219947 and above, by increasing the number of passes compared to conventional condenser designs (which typically have four or less passes) at  
30 least comparable thermal performance is achieved.

The hydraulic diameter of refrigerant flowpaths in a respective pass is preferably substantially at or above 1.6mm. Most preferably, the hydraulic diameter of passes is substantially at or above 1.75mm.

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A further benefit and significant advantage is that, particularly at flowpath hydraulic diameters in the preferred range, reduced refrigerant pressure drop is found to occur across the condenser. This is of significant technical benefit in that the overall system energy requirements are reduced.

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Desirably, the number of refrigerant passes across the condenser is 10 or less.

15

The refrigerant flowpaths are preferably substantially parallel to one another across the condenser. The condenser is desirably air cooled.

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The refrigerant flowpaths typically comprise tubes (preferably flattened tubes) extending across the condenser, the tubes preferably including internal flowpath dividers arranged to divide the tube into a plurality of flowpaths. The internal flowpath dividers may comprise inserts for respective tubes. An airflow matrix is preferably provided intermediate adjacent tubes. The airflow matrix preferably comprises a series of fins or louvres.

25

30

The number of tubes in at least one pass grouping is preferably substantially in the range 2 to 12. The number

of tubes in the most upstream grouping is preferably substantially in the range 12 or less.

5 The condenser comprises spaced headers between which the refrigerant flowpaths extend. The headers preferably include internal dividers directing the flow of refrigerant along adjacent passes through respective groups of refrigerant flow paths.

10 Flowpaths in an upstream pass grouping preferably have a greater effective cross sectional area than flowpaths in a downstream pass group.

15 The invention will now be further described in a specific embodiment by way of example only, and with reference to the accompanying drawings, in which:

Figure 1, is a schematic representation of an exemplary condenser according to the invention;

20 Figure 2, is an end view of a condenser tube used in the condenser of figure 1;

25 Figure 3 is a graphical representation of condenser performance characteristics for prior art condensers and condensers according to the invention; and,

30 Figure 4, is a further graphical representation of condenser performance characteristics for prior art condensers and condensers according to the invention.

Referring to the drawings and, initially to Figures 1 and 2, there is shown a condenser (generally designated 1) for use in an automotive air conditioning system. The condenser 1 comprises a pair of spaced headers 2, 3; header 2 is provided with an upstream inlet 4 for refrigerant vapour, whereas header 3 is provided with a downstream condensate outlet 5. (For a six pass condenser, both inlet and outlet would be in the same header.) In passing through the condenser 1, the refrigerant enters via inlet 4 in vapour phase and passes, in succession, through banks 7a, 7b, 7c, 7d and 7e of condenser tubes 6 before the refrigerant condensate exits via outlet 5.

In the embodiment described, there are five banks of tubes 7, each bank comprising a series of tubes 6 extending between the headers and spaced by inter-tube airways permitting cooling air to be drawn (typically by a fan) through the condenser in an airflow direction transverse to the longitudinal direction of tubes 6. The airways may be defined by inter-tube fins defining an airway matrix of maximum heat transfer area as is conventional in the condenser art and described in, for example, EP-B-0219974.

For performance of the invention it is required that at least five banks 7 of tubes 6 are provided, requiring the refrigerant to undergo a minimum of five passes across the heat exchanger before exiting via outlet 5. This is greater than the conventional number of passes employed in known condensers. Furthermore, the number of tubes per pass (particularly the refrigerant pass via initial bank

7a) is reduced compared to known heat exchanger types. In the five pass embodiment shown in Figure 1, the arrangement has tubes 6 in each bank as follows:

|    |             |                        |
|----|-------------|------------------------|
| 5  | <u>Bank</u> | <u>Number of Tubes</u> |
|    | 7a          | 12                     |
|    | 7b          | 9                      |
|    | 7c          | 7                      |
|    | 7d          | 4                      |
| 10 | 7e          | 3                      |

(Other embodiments of five pass condensers may have other tube number arrangements. In a six pass condenser according to the invention utilising six banks 7 of tubes 6, an arrangement suggested might be 10-7-6-5-4-3 but could be other combinations.)

In condensers according to the invention for which tests have been carried out, each tube 6 includes a number of internal divisions defining smaller flow channels 8, such that the hydraulic diameter of the channels 8 (and for each tube 6) is approximately 1.730mm. Experimental evidence suggests that for performance of the invention, the hydraulic diameter needs to be at least 1.5mm (preferably at least 1.65mm).

The headers 2, 3 are provided with internal baffles 9 ensuring that the refrigerant follows a serpentine path through the condenser to flow along a path through adjacent banks (7a, 7b; 7b, 7c; 7c, 7d; 7d, 7e) in opposed pass directions across the condenser 1.

It has been found that by providing the condenser having five and more passes across the condenser (particularly where hydraulic diameters are in the range mentioned above), desirable condenser performance characteristics are achieved when compared with other forms of known condensers.

Referring to Figure 3, in the graph, curve A represents the performance of a known type 4-pass condenser having a Hydraulic Diameter (Dh) of 1.023 mm (falling within the range specified in EP-B-0219974). Curve C represents characteristics of a condenser according to the invention having a five refrigerant pass regime, as described above and shown in Figure 1, in which the number of tubes 6 per pass (i.e. per bank 7) are arranged as follows from inlet to outlet (12-9-7-4-3). Curve B represents a condenser according to the invention having six passes (i.e. banks 7) having from inlet to outlet banks 7 including 10-7-6-5-4-3 tubes per bank/pass respectively. The Hydraulic Diameter (Dh) of the tubes in the condensers represented by curves B and C are 1.730mm.

Figure 4 shows corresponding curves for A, B and C detailing refrigerant pressure drop and refrigerant flow rate.

As shown in Figures 3 and 4, the increased number of passes for condensers according to the invention (curves B and C) provides thermal performance characteristics approaching closely the performance of condensers falling in the range of EP-B-0219974. As also shown in Figure 3,

the air side pressure drop is not significantly affected when compared to the known condenser.

5 Furthermore, as shown in Figure 4, the five and six pass  
condensers 1 of the invention (curves B and C) exhibit  
significantly less refrigerant pressure drop across the  
condenser than the known condenser (curve A). This means  
that the refrigeration system compressor is required to  
10 carry out less work and results in overall energy savings  
for systems employing condensers according to the  
invention.

The beneficial reduction in pressure drop for a given  
15 performance level is unexpected and offers potential  
benefit in refrigeration and air conditioning systems,  
particularly where refrigerant pressures and pressure  
losses are significant. Such a situation could, for  
example, be in sub-cooling systems where condensing  
pressures are increased as a direct consequence of reduced  
20 condensing volumes.

A further benefit of the invention is that it enables  
adequate condenser performance to be achieved outside the  
Hydraulic Diameter range specified in EP-B-0219974.

Claims:

1. A condenser for use in an air conditioning or refrigeration system, the condenser comprising a plurality of refrigerant flowpaths extending adjacent one another, flowpaths being grouped such that adjacent groups carry refrigerant passes in opposed directions across the condenser, wherein the arrangement of groups is such that the number of refrigerant passes across the condenser is 5 or above.
2. A condenser according to claim 1, wherein the arrangement of groups is such that the number of refrigerant passes across the condenser is 6 or above.
3. A condenser according to claim 1, wherein the arrangement of groups is such that the number of refrigerant passes across the condenser is 7 or above.
4. A condenser according to claim 1, wherein the arrangement of groups is such that the number of refrigerant passes across the condenser is 8 or above.
5. A condenser according to any of claims 1 to 4, wherein the number of refrigerant passes across the condenser is 10 or less.
6. A condenser arrangement according to any preceding claim, wherein refrigerant flowpaths comprise tubes extending across the condenser.

7. A condenser according to claim 6, wherein the number of tubes in at least one pass is substantially in the range 2 to 12.
- 5 8. A condenser according to claim 7, wherein the number of tubes in the most upstream group is substantially in the range 12 or less.
- 10 9. A condenser according to any preceding claim wherein the hydraulic diameter of paths in a respective pass is substantially at or above 1.5mm.
- 15 10. A condenser according to any preceding claim, wherein the hydraulic diameter of passes is substantially at or above 1.8mm.
- 20 11. A condenser according to any preceding claim, wherein flowpaths in an upstream pass grouping preferably have a greater effective cross sectional area than flowpaths in a downstream pass group.
- 25 12. A condenser according to any preceding claim, wherein the condenser comprises spaced headers between which the refrigerant extends.
- 30 13. A condenser according to claim 12, wherein the headers include internal dividers directing the flow of refrigerant along adjacent passes through respective groups of refrigerant flow paths.
14. A condenser according to any preceding claim wherein

the refrigerant flow paths comprise tubes extending across the condenser, the tubes including internal flowpath dividers arranged to divide the tube into a plurality of flow channels.

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15. A condenser according to claim 14, wherein the internal flowpath dividers comprise inserts for respective tubes.

10

16. A condenser according to any preceding claim, wherein the refrigerant flowpaths comprise flattened tubes extending across the condenser.

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17. A condenser according to any preceding claim, wherein the refrigerant flowpaths comprise tubes extending across the condenser an airflow matrix being provided intermediate adjacent tubes.

20

18. A condenser according to claim 17, wherein the airflow matrix comprises a series of fins.

19. A condenser substantially as herein described with reference to the accompanying drawings.



Application No: GB 9903050.4  
Claims searched: 1-19

Examiner: Kalim Yasseen  
Date of search: 29 April 1999

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): F4H (HGXB, HG17)

Int Cl (Ed.6): F25B 39/04; F28F 9/02, 9/22

Other: Online: EPODOC, JAPIO, WPI

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage  | Relevant to claims |
|----------|--|--------------------|
| X        | EP 0 769 666 A1 (CALSONIC) a condenser having a refrigerant flow path with a plurality of turns                          | at least 1-14, 18  |
| X        | US 5 752 566 A (FORD) a condenser having a refrigerant flow path with a plurality of turns                               | at least 1-14, 18  |
| X        | US 5 730 212 A (NIPPONDENSO) see whole document for a condenser having a refrigerant flow path with a plurality of turns | at least 1-14, 18  |
| X        | US 5 228 315 A (ZEXEL) a condenser having a refrigerant flow path with a plurality of turns                              | at least 1-14, 18  |
| X        | US 5 076 354 A (DIESEL) see figure 1 for a condenser having a refrigerant flow path with 5 turns                         | at least 1-14, 18  |

X Document indicating lack of novelty or inventive step  
Y Document indicating lack of inventive step if combined with one or more other documents of same category.  
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